WINTER BUILDING

An interim review by the

Committee on Winter Building

Still Life

FOREWORD

by the Minister of Public Building and Works

This booklet has been prepared by a technical committee which I appointed in June, 1963, to make an urgent inquiry into the problems of winter building. It draws on existing sources and sets out information likely to be of value to medium-sized building firms. There are many problems about which we need to know more, especially in regard to cost, but I thought it important to make the existing information available in a convenient form, before another winter is upon us. The committee are continuing their work.

Although some of the measures available to maintain production during bad weather involve additional cost, this interim review makes clear that there are many simple precautions which can be taken at very little cost. If it leads to a greater awareness of these, and stimulates thought and discussion, it will have served its purpose.

I am grateful to the committee for the speed and enthusiasm with which they have approached their task, and to all those who have helped them.

COMMITTEE ON WINTER BUILDING

Terms of Reference

'To study the problems of winter building, and in particular to review the work which has already been done and information which already exists in this and other countries, to enable an interim report, in the form of an attractive pamphlet, to be produced by the early autumn; to identify and recommend further fields for investigation and research.'

Membership

Chairman:	I. T. M. Davis, M.C.D., B.Arch., A.R.I.B.A., A.M.T.P.I.	Associate Partner, Farmer & Dark, Chartered Architects.
Members:	E. O. Baillie	Director, Gilbert-Ash Ltd.
	R. Foster, F.I.O.B.	Managing Director, M. & F. O. Foster & Co. Ltd.
	K. A. Maclean, F.R.I.C.S.	Partner, Langdon & Every, Chartered Quantity Surveyors.
	E. A. Woolnough, B.Sc.Tech., M.I.Struct.E.	Assistant Chief Design Engineer, Taylor Woodrow Construction Ltd.
Secretary:	P. J. Rodwell	Ministry of Public Building and Works.

Observers

J. H. Mills, C.B.E.	President, National Federation of Building Trades Operatives.
E. Thompson, B.Sc.	Technical Officer, National Federation of Building Trades Employers.

Officers of the Building Research Station assisted the committee on certain aspects of the investigation.

FOREWORD BY THE COMMITTEE

The time available for the completion of the first part of the committee's initial task, i.e. the production of an interim report or review, was eight weeks. The committee first met on 6th June, 1963, and completed this review on Thursday, 1st August, 1963.

They decided that their terms of reference called for an appraisal of practical work already performed in the field of winter working, and an examination of documentary information originating both in this and in other countries.

To achieve this the committee's programme of work included:

(a) Examination of a wide range of technical books, articles and papers.

(b) Discussions with selected builders in the Home Counties, with trades associations and federations, with the Building Research Station, with departments of the Ministry of Labour, the Ministry of Public Building and Works and the Meteorological Office, and with departments and building organisations in Scotland.

(c) The analysis of questionnaires issued through the medium of federations and associations and completed by members. The issue of questionnaires was carried out in two stages, the one being on a strictly limited circulation for use in the first phase of the investigation and the other on a much wider circulation for use in the second.

(d) Consideration of replies to requests by the committee for advice and information.

Insufficient time was available during the preparation of the review either for extensive discussion with individuals, firms or other bodies, or for assimilation of all the information in writing addressed to the committee. All material received will, however, be thoroughly processed and evaluated.

The committee has so far found itself under a handicap in that, during summer time, all information is necessarily obtained at second or third hand. There has been no opportunity to witness work in progress under winter conditions.

To assist those who wish to make further study of particular aspects of the problem, a bibliography of the more significant works read by the committee is included in Appendix III.

The second part of the committee's initial task, namely the identifying and recommending of further fields for investigation and research will entail a detailed study of specific problems. The committee's findings will be embodied in a report to the Minister.

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THE ECONOMICS OF WINTER

The cost of winter

1

In recent history, this country has experienced only three severe winters, in 1939/40, in 1946/47 and in 1962/63. During the first two, because of the war and its aftermath, the impact of severe weather upon production attracted little attention. By December, 1962, the industry's vast expansion had brought it to the forefront of the nation's industrial effort, and the months of frost which followed ruthlessly exposed its vulnerability to severe winter weather.

2

The alarming loss of production in those early months of 1963 dramatised an event which occurs annually although on a lesser scale each winter, operations are cut back and the labour force is reduced Figure 1 opposite demonstrates the value of output achieved and what could have been achieved had the industry's growth continued uninterrupted by the winter period. It may well be, but for this seasonal decline, that the rate of growth would have been faster. As significant as this annual winter recession, is the slow recovery each Spring Full production is not achieved again until the early Summer.

3

The effects are widespread and complex, and the cost, to the extent that it may be reckoned, is:

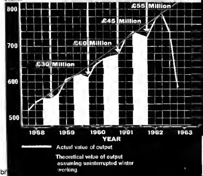
(a) **To the individual builders**

Adverse weather conditions lead to the underemployment of men, plant and machinery, and fixed assets, and in this situation profits will be lower: there may, indeed, be an actual loss Less easy to assess in monetary terms is the loss of good men, necessarily paid off, and of the goodwill of clients who do not understand the difficulties.

(b) **To the operatives**

Those who are fortunate, and remain in employment, will probably at some period of the winter receive only the guaranteed minimum weekly wage. This, coupled with the shorter working hours, will entail a loss of earnings. More serious is the position of the 30,000 to 50,000 men who are laid off, and who on this account lose pay amounting to between £6 million and £11 million per year. In 1962/63, which was exceptional, nearly 160,000 men were laid off at one stage, and this entailed losses of pay of, perhaps, £30 million. Purchasing power is thus lost to the economy, but more

Fig 1 ASSESSED LOSS OF OUTPUT



Important is the hardship for the men and their families, which unemployment benefit and national assistance, estimated at £12 million for the winter of 1962/63, cannot fully alleviate

(c) To the industry as a whole
There is a steady drain from the industry of men over the age of 35 years, who seek better working conditions and greater security elsewhere. This is a serious loss at a time when the building programme demands an increase in the size of the labour force

(d) To the nation
The nation suffers in at least two ways. One is from the delay in construction of buildings which in themselves contribute to an increase in wealth. Another is from the loss of purchasing power arising from the lower 'take home' pay of operatives still in employment and the loss of wages by the unemployed this may well lead to unemployment elsewhere. The repercussions of this seasonal loss are felt throughout the retail trades, and eventually throughout the nation's economy

4

There has in the past been a tendency to accept the disruption of bad weather as a natural part of the building scene, and this may well have contributed to sociological difficulties within the industry. It has now to be considered whether an industry having an important part to play in the economy of a country struggling to increase its general productivity, can afford passively to accept a loss of production brought about by bad weather.

5

Builders in Canada, Scandinavia and Russia, and some in this country, have, over the last few years, been proving the practicability of continuing to work throughout the winter. With the technical knowledge and equipment now at their disposal, they are able to maintain production in almost any weather.

Meeting the cost of winter building

6

Although production can be maintained it will generally cost more, and it is necessary to consider how the additional cost is to be met.

7

Builders who have achieved some measure of continuous production have realised that even though the cost is greater, it is more economical than having to sustain continuing overheads with reduced production. Some expenditure on winter working is therefore justified on these grounds alone, but possibly not sufficient to make it possible to maintain full production.

8

Who then is to pay direct costs which may be incurred in winter working? This question of payment must be resolved if the building industry is to become less vulnerable to winter weather and if production is to be increased This is no simple problem because of the difficulty of assessing what share of the direct costs of winter working the building owner, the builder, and the State should meet, since all benefit in some degree.

9

It is apparent, however, that some of the money at present being spent on Unemployment Benefit and National Assistance could be better spent on measures to maintain full employment and continued production. Not only would this alleviate distress of those thrown out of work through no fault of their own, but the nation as a whole would benefit from the increased output of houses, factories, hospitals and of other buildings which would be of real value to the community.

10

Serious issues for the building industry and for the nation are raised here. The committee believes that they should be given urgent consideration by all concerned in order to utilise to the full the building industry's potential throughout the year.

WEATHER

11

The following paragraphs do not purport to give a detailed description of British weather. They are notes for the guidance of readers who have made little study of this subject.

Temperature and frost

12

Figure 2 shows the average number of days per year during the period 1913-1940 in which the minimum temperature was 32°F. (0°C.) or less. It will be seen that the mountainous areas of Scotland and northern England are most liable to frost whilst the south-west is least affected.

13

The frequency of frost depends not only upon altitude and distance from a coast, but on other factors of local topography. In open country, for example, on clear nights with light winds, the air near the ground is cooled by radiation and begins to flow downhill, and pools of cool air accumulate in valleys. Such valleys or hollows are known as 'frost hollows'. Recorded frosts in these hollows are likely to be greatly in excess of those in the surrounding areas.

14

Soil temperatures are not affected to any very great depth by rapid variations in air temperature. Long period variations in air temperature reach the greater depths only after considerable delay. Some soils are more resistant to temperature change than others and are thus slower to freeze and slower to thaw out. Further information on the subject is given in Appendix I.

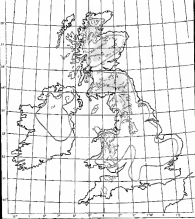


FIG. 2
Average annual frequency of days with minimum temperature, 32°F. (0°C.) or less 1913-40

▨ 100 days

— 30 days

15

Surface temperatures of buildings may differ considerably from air temperatures. Surfaces lose heat by radiation all the time, especially during nights when the sky is clear, and this tends to lower their temperatures. The temperature of a surface depends not only upon the difference between incoming and outgoing radiation, but also on other factors such as wind speed and the thermal characteristics of the type of construction behind.

Humidity

16

In general, levels of humidity are highest in coastal areas and lowest inland. In summer, the areas with least humidity are to be found on the line of the Welsh border and in the Home Counties, and those with the greatest in the south-west of England.

17

All air in its natural state contains water vapour, but a volume of air at a given temperature can hold only a certain maximum. The amount of water vapour needed to saturate a given volume of air increases with temperature. Condensation is caused when very moist air meets a colder surface, cools, becomes super-saturated, and deposits on the surface some of its water.

Rainfall

18

So substantial are the variations in rainfall between one year and another that it is difficult to set out any conclusions which might be of value to the construction industry. It is widely known that the mountainous areas of the north and west receive a heavy rainfall, whilst in the east, rainfall is comparatively slight.

19

The graph opposite shows the average number of hours between 6 a.m. and 6 p.m. in each month of the year in which rain fell at a rate of 0.5 mm. per hour or more in London, Manchester and Glasgow. This rate of fall, which corresponds to the upper limit of slight rain, has been postulated by the Meteorological Office as the level at which outside work will be affected.

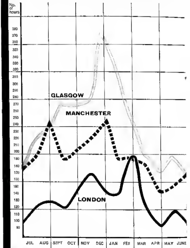


FIG. 3

Comparison between incidence of rainfall at an intensity of 0.5 mm/hour or more in London, Manchester and Glasgow

Total hours per month of rainfall and snow of equivalent value between 6 a.m. and 6 p.m. at intensity of 0.5 mm/hour or more

Snow and hail

20

The frequency of snow lying on the ground is one of the most variable factors in British weather. Statistics show that the average annual number of days with snow falling on low ground increases with latitude from less than five days in southern Cornwall to more than 35 days in north-east Scotland. At places above 200 feet, the average number of days increases by about one day for every 50 feet of elevation.

21

The depth of undrifted snow does not often exceed six inches on level ground at low altitudes, but drifts of several feet in depth may be formed by wind action.

22

Although hail is not infrequent, only rarely are the hailstones of sufficient size to cause damage. Destructive hailstones seem to be most common in south-east England and in the east Midlands.

Wind

23

The highest hourly mean wind speeds which have been recorded reached about 70 miles per hour on exposed western coasts and about 60 miles per hour on exposed eastern coasts. Sudden gusts may rise in speed to 100 miles per hour or more. In inland areas, wind speeds are generally some 10 miles per hour less than in coastal areas, and in built-up areas some 20 miles per hour less; sudden gusts, however, have the same speed in built-up areas as in open country.

24

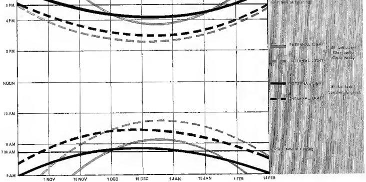
Gales are most frequent on the western seaboard and least frequent inland. Maximum frequency is in December and January, but they occur at any time of the year.

Light

25

The following graph shows the times of day during winter in which artificial light will be needed to enable work to continue:

FIG. 4 APPROXIMATE TIMES WHEN LIGHTING IS REQUIRED FOR BUILDING WORK



The effects

26

Any one of the factors described can exercise a delaying effect on production, but the worst effects arise when snow, high winds and sub-zero temperatures are in combination. Some of the difficulties created for the builder by these factors are described in the table opposite.

Anticipating bad weather

27

The uncertain nature of the British climate discourages builders from committing themselves to expenditure on precautions which may prove unnecessary. The use of meteorological services may partially overcome this difficulty.

28

National and regional forecasts are given in sound and television broadcasts and in the press. Local forecasts may be obtained free of charge by telephoning the local Meteorological Office. Site forecasts, obtainable for a small charge, can either give warning of the imminence of a specific weather condition, such as a drop in temperature below a given point, or provide a comprehensive forecast at stated intervals. Also, the Meteorological Office will, on application, assess the probability of severe weather in a given area on a basis of past experience. These services may be a valuable aid to planning.

29

The need for reliable medium and long-range forecasting for the building industry, as well as for other spheres of activity, is obvious, and considerable progress in this field has already been made. Regular long-range weather forecasts are given by the meteorological institutes of some countries, but there is considerable difference of opinion as to their value. In this country, the Meteorological Office does not issue long-range forecasts, but the matter is under study and the results of research are at present being evaluated. Long-range weather forecasts may, however, be obtained from private consultants.

30

Appendix II sets out the services which are available to builders.

Table 1 – Effects of Weather

Phenomenon	In conjunction with	Effect
Rain		1. Affects site access and movement. 2. Spoils newly finished surfaces 3. Delays drying out of buildings 4. Damages excavations 5. Delays concreting, bricklaying and all external trades 6. Damages unprotected materials 7. Causes discomfort to personnel. 8. Increases site hazards.
	High wind	1. Increases rain penetration 2. Reduces protection offered by horizontal covers. 3. Increases site hazards
High wind		1. Makes steel erection, roofing, wall sheeting, scaffolding and similar operations hazardous. 2. Limits or prevents operation of tall cranes and cradles, etc 3. Damages untied walls, partially fixed cladding and incomplete structures. 4. Scatters loose materials and components. 5. Endangers temporary enclosures.
Low and sub-zero temperatures		1. Damages mortar, concrete, brickwork, etc 2. Slows or stops development of concrete strength 3. Freezes ground and prevents subsequent work in contact with it, e.g. concreting 4. Slows down excavation 5. Delays painting, plastering, etc 6. Causes delay or failure in starting of mechanical plant. 7. Freezes unlagged water pipes and may affect other services 8. Freezes material stockpiles. 9. Disrupts supplies of materials. 10. Increases transportation hazards. 11. Creates discomfort and danger for site personnel 12. Deposits frost film on formwork, steel reinforcement and partially completed structures.
	High wind	Increases probability of freezing and aggravates effects of 1-12 above.
Snow		1. Impedes movement of labour, plant and material. 2. Blankets externally stored materials 3. Increases hazards and discomfort for personnel 4. Impedes all external operations 5. Creates additional weight on horizontal surfaces
	High wind	Causes drifting which may disrupt external communications.

PRE-CONTRACT MATTERS

Design

31

At the development stage of a project in this country, the selection of structural methods is not normally influenced by winter conditions, unlike practice in countries where winters are predictably severe.

32

There are certain types of buildings on which considerable development work has been carried out, resulting in forms of construction which are less vulnerable to winter conditions. The use of factory-made components, combined with the development of dry assembly on site, possesses obvious advantages for continuous winter production. Industrialisation and prefabrication have advantages in reducing delays normally experienced with traditional methods, but there must be a continuous building programme to enable these to be economic.

Contract

33

Most building contracts include a clause dealing with adverse weather conditions and, although there is variation in wording, the general intent and effect is that the builder is permitted an extension of the agreed contract period if he is unable to continue work because of unfavourable weather conditions. The view has been expressed that the inclement weather clause enables contractors to obtain extensions of contract periods too readily, and that its removal or amendment could encourage winter building. Certain suggestions have been made to the committee for amendments to the standard form of contract. These, together with some of the more obvious observations upon them, are set down with the intention of provoking thought within the industry, but it is the committee's view that no steps should be taken to implement any of these proposals until further detailed study has taken place and the views of all interested parties obtained:—

(a) **If the 'inclement weather' clause were removed entirely from building contracts, bad weather would no longer be one of the reasons by which a contractor could claim an extension of the contract period.** When tendering, the contractor would be gambling on the weather, and some cover for his gamble would no doubt go into the contract sum. If builders protected themselves from the possible effects of bad weather on their programme by addition to the tender price, the cost of building would increase and, in winters where conditions proved to be less severe than anticipated by the tendering contractors, building owners would be paying for protective and other measures which were not carried out.

(b) **To include in the contract a provisional sum which may be expended by the architect or officer supervising the contract, on measures to keep work going in bad weather.** The building owner would pay only for such measures as were required and authorised and would not be faced with extension of the contract period due to bad weather. The contractor would not be faced with the risk of under provision for winter working in his tender. It is possible that difficulties would arise over the assessed need and the type of measures to be adopted under cover of the provisional sum, especially as some measures, to be successful, must be taken prior to commencement of bad weather. However, these difficulties are not insuperable.

(c) **To qualify the 'inclement weather' clause by defining specific climatic conditions in which the contractor will be required to carry out the work at the terms in his tender.** In these climatic conditions, the contractor would have no claim for extension of contract time. In conditions worse than those specified in the contract, it would be at the client's discretion to require the contractor to continue work or permit him to stop. In the first case, the contractor would be reimbursed for his extra costs: in the second he would be entitled to an extension of time.

Specification

34

Specification clauses in building contracts have tended to prohibit work when given climatic conditions are reached on the building site. Clauses which say that concreting must stop at x°F on a falling thermometer are familiar to most builders. It may be considered that specifications should be concerned, when dealing with cold weather work, not solely with air and ground temperatures, but with the temperature of the work and conditions in which it is placed. The builder should be asked to produce work of the requisite strength and durability, and he should not be stopped from working at temperatures and in conditions where there is ample proof that work can continue safely. The decision to continue work in freezing temperatures is one which will need to be taken only by those fully experienced and competent to judge the overall effects.

Planning

35

The overall planning and co-ordination of the placing of contracts by public bodies can ensure an even flow of new orders into the industry through the year. This is a prerequisite of ensuring maximum utilisation of the industry's resources. The planning and phasing of work within the individual company can produce similar benefits.

36

The importance of planning all stages of the building operation is now widely appreciated. Many firms employ specialist planners, but those requiring advice and assistance on planning may obtain it from the Building Advisory Service, the Institute of Builders, technical colleges or from private management consultants.

37

Planning presents a complete picture of the whole building operation to all levels of management. Its chief significance in winter working is in the emphasis it places upon key operations which must be completed by a certain stage. A detailed operational programme enables the builder to determine the scope and nature of protection for key operations, and to make provision before winter starts. It also identifies reserve jobs under cover for outside workers. It must be sufficiently flexible to take account of the weather and of unforeseen contingencies. "Critical path" analysis is worthy of study in this connection (see Item 4 of Appendix III).

38

Planning enables the builder to consider

(a) composition and strength of the labour force

(b) economic use of plant and equipment, and the selection of types to suit winter conditions

(c) correct phasing for deliveries of materials and components

(d) progressing of specialists' and sub-contractors' work into the correct sequence of building operations

(e) need for acceleration of particular sections of the work to render the building weathertight

(f) necessity for the early provision of a permanent or temporary site road and drainage system

(g) necessity for shelters, screens or other protective measures and their programming through the contract

(h) provision for defrosting materials, and for defrosting ground or maintaining it frost free

(i) requirements for lighting the site, plant areas and works.

(j) suitability of alternative materials

(k) disposition of site accommodation, storage facilities and working areas, and the selection of temporary buildings suitable for winter conditions

(l) extent of maintenance requirements for plant and equipment

(m) need for specialised meteorological information

(n) quantity and type of protective clothing, the provision of heated mess accommodation, clothing storage, drying facilities, other site amenities and transport for operatives

KEEPING THE WORK MOVING

Transportation

39

Most raw materials and components for the building industry reach the site by road. In severe winter weather, the speedy clearance of ice and snow from roads is therefore of vital interest to the building and associated industries.

40

Delays in the delivery of materials due to the condition of the roads, are infrequent and usually of short duration Severe winters may, however, cause severe disruption and delay, particularly to builders working in isolated areas. It is clear from recent experience, that some local authorities are better equipped than others to deal with the problem of snow clearance.

41

Communications to the site are largely out of the builder's hands, but communications on the site are his to manage. A builder should plan his site and communications as he does his building, but some building sites, especially in winter time, present a sorry spectacle

42

Firm based roads to permit vehicle access right up to the points of delivery are essential if bogging down of transport and double handling of materials is to be avoided. If the site's own eventual road system will provide this so much the better, as the base or foundation courses may then be laid at the beginning of the contract, used as temporary roads during the contract, and completed with their finishing courses when the movement of heavy vehicles has ceased If the permanent road system cannot be used, temporary roads may be laid using timber sleepers, clinker, hardcore or metal tracks. Stabilised earth techniques may also be employed.

43

Site roads, once provided, must be maintained and, in the winter, kept clear of snow. Types of vehicles which are vulnerable to bogging down and starting difficulties should be avoided where suitable alternatives are available. Skid chains will generally assist mobility of vehicles on the site.

Excavation and other operations in frozen ground

44

Modern excavating machinery can operate successfully in ground frozen to a depth of twelve inches and back acters have been used on ground frozen to a depth of eighteen inches. Machinery of half a cubic yard capacity or less will, however, have difficulty, but irrespective of the capacity of the excavator, the speed of excavation will be reduced with consequent increase in cost Other methods of excavating in frozen ground have been used, including compressed air tools, explosives and undercutting and collapsing

45

To avoid the difficulties referred to in the preceding paragraph, if frosts are expected and the work is essential, then the ground may be protected to prevent freezing. The most common covering is straw, but steam lines under tarpaulins have been used, and suitable insulation under tarpaulins would also be effective. Abroad, use has been made of brushwood, wood shavings, clinker and other locally available materials.

Straw and covers protecting concrete

46

If it is necessary to defrost the ground, this may be effected by means of flame throwers or steam. Steam may be applied by jets, by thin coils laid on the ground or by steam points melting their way into the surface. Defrosting has been carried out in other countries by burning coal, straw, wood scraps or other inflammable materials over the area to be excavated. When construction is to continue, it is vitally important to check that the thawing out process has been thoroughly carried out, and that steps are taken to prevent subsequent refreezing of ground below newly placed concrete or brickwork.

47

There are occasions when freezing of the ground simplifies problems of excavation, since it improves access across normally difficult or soft areas. It can also give temporary stability to earth slopes and embankments, thereby assisting operations such as pipe laying.

48

After excavation, the surface of the ground must be protected to prevent freezing. When it is possible to pour concrete immediately, protection such as straw or tarpaulins must be provided to prevent night frosts penetrating the ground adjacent to or under the concrete. Exposed basement or ground slabs which have matured may require top protection to prevent cold travelling through to the subsoil and causing subsequent frost-heave.

49

As a general rule, frozen materials should not be used for backfilling or filling where proper consolidation is required, since thawing will result in subsequent settlement.

Maintenance of essential services and plant

50

Water supplies carried in temporary pipelines above ground level require protection. In planning pipe routes, the possibility of freezing should be borne in mind, and the installation of ring mains and stop cocks at suitable points will help to locate and isolate bursts, and permit a partial supply to be maintained. Long lengths of rubber or plastic hose may be used in place of conventional pipe-work. These require draining and storing at night. Pumps should always be drained and protected. The following protective measures are also available:

(a) the arrangement of pipes so that they may be drained on completion of each day's work, or lagging. Standpipes are particularly vulnerable and should be well insulated. Extended spindles may facilitate the insulation of valves

(b) the use of electrical means of protection. Before any of these are adopted, however, expert advice must be obtained. Means which have been employed are the use of a low voltage cable wound round the pipe through which a current is passed, and the use of the pipe itself as an electrical conductor.

51

Electricity supplies are liable to failure due to the coating of vulnerable components, such as contacts, with moisture, frost or ice. These parts should be fully protected. Precautions should be planned in consultation with the electricians.

52

Gas pipes which are likely to be affected by freezing of condensation should be lagged and **compressed air mains** fitted with drain plugs.

53

Plant cannot normally be kept completely under cover when not in use. The vital parts should, however, be protected in order to avoid loss of time each morning in starting. The following simple precautions are normally taken:

(a) grades of oil, lubricating compounds, radiator antifreezes, etc., are selected in accordance with the maker's recommendations for the conditions anticipated.

(b) engines and electrical systems are well covered. Radiators are drained when necessary.

(c) wheeled and tracked vehicles are run up onto baulks of timber to prevent their freezing to the ground.

(d) where tyres have been partially filled with water to improve traction, anti-freeze is added.

Major defrosting of working parts is sometimes necessary before plant is able to operate.

Winning of Materials

54

The winning of materials is not, as a rule, badly upset by winter weather and most producers consider that, given reasonable forecasting of demands by consumers, stock piles at the pits and quarries can provide for all but prolonged spells of bad weather.

55

Sand and gravel suppliers are faced with the problem that wet pits are vulnerable to severe winter conditions, but most can meet demands, particularly if these are known in advance, from alternative sources of supply which can be chosen to suit specifications.

56

Other problems arising are the increased danger of damage to plant and machinery, which may be alleviated by the use of heat and protective coverings, and the freezing of stockpiles which may be overcome by the use of steam, and of equipment to break into frozen piles. Material thawed ready for delivery should be protected both at the pit and in transit. After heavy snow, an improvised snow plough may be needed to ensure access to the pit, and in rural areas it will be necessary, if public transport has broken down, to provide transport for the operatives.

Provision of temporary protection

57

Until recently, the need for enclosures has been generally accepted only for offices, messrooms and materials subject to damage by rain or snow. It is general practice for specifications to prescribe that work shall be covered when frost conditions are anticipated, but otherwise, there is considerable variation in the extent to which works, plant and materials are protected

58

The purposes of providing temporary protection are to protect work under construction, to enclose a section of the site or building to enable the temperature to be raised, to provide better conditions for operatives, or to protect materials on the site.

59

At the beginning of a contract, the cost of ensuring reasonable means of protection for vulnerable works and plant must be weighed against the cost of delays and possible damage to new work. The methods of protection should be studied with a view to maximum utilisation, and the necessary protective materials should be allocated at the outset of the job. In the course of programming the work, the sequence of operations may often be arranged so that work in covered areas is available for outside workers in severe winter weather.

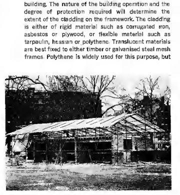
60

The principal forms of protection used for building operations are shelters (total enclosures, roofs, side walls or drapes), windbreaks and contact covers. Each is discussed in some detail in the following paragraphs.

61

Shelters may provide for total enclosure of the working areas, or for the roof or side walls only. They are divisible into three groups:—

(a) **scaffolding enclosures** which consist of sheet materials fixed to a framework, usually the scaffolding of the building. The nature of the building operation and the degree of protection required will determine the extent of the cladding on the framework. The cladding is either of rigid material such as corrugated iron, asbestos or plywood, or flexible material such as tarpaulin, hessian or polythene. Translucent materials are best fixed to either timber or galvanised steel mesh frames. Polythene is widely used for this purpose, but


Temporary roof covering.

Straw and covers protecting concrete.

46

If it is necessary to defrost the ground, this may be effected by means of flame throwers or steam. Steam may be applied by jets, by thin coils laid on the ground or by steam points melting their way into the surface. Defrosting has been carried out in other countries by burning coal, straw, wood scraps or other inflammable materials over the area to be excavated. When construction is to continue, it is vitally important to check that the thawing out process has been thoroughly carried out, and that steps are taken to prevent subsequent refreezing of ground below newly placed concrete or brickwork.

47

There are occasions when freezing of the ground simplifies problems of excavation, since it improves access across normally difficult or soft areas. It can also give temporary stability to earth slopes and embankments, thereby assisting operations such as pipe laying.

48

After excavation, the surface of the ground must be protected to prevent freezing. When it is possible to pour concrete immediately, protection such as straw or tarpaulins must be provided to prevent night frosts penetrating the ground adjacent to or under the concrete. Exposed basement or ground slabs which have matured may require top protection to prevent cold travelling through to the subsoil and causing subsequent frost-heave.

49

As a general rule, frozen materials should not be used for back-filling or filling where proper consolidation is required, since thawing will result in subsequent settlement.

Maintenance of essential services and plant

50

Water supplies carried in temporary pipelines above ground level require protection. In planning pipe routes, the possibility of freezing should be borne in mind, and the installation of ring mains and stop cocks at suitable points will help to locate and isolate bursts, and permit a partial supply to be maintained. Long lengths of rubber or plastic hose may be used in place of conventional pipe-work. These require draining and storing at night. Pumps should always be drained and protected. The following protective measures are also available:

(a) the arrangement of pipes so that they may be drained on completion of each day's work, or lagging. Stand-pipes are particularly vulnerable and should be well insulated. Extended spindles may facilitate the insulation of valves.

(b) the use of electrical means of protection. Before any of these are adopted, however, expert advice must be obtained. Means which have been employed are the use of a low voltage cable wound round the pipe through which a current is passed, and the use of the pipe itself as an electrical conductor.

51

Electricity supplies are liable to failure due to the coating of vulnerable components, such as contacts, with moisture, frost or ice. These parts should be fully protected. Precautions should be planned in consultation with the electricians.

52

Gas pipes which are likely to be affected by freezing of condensation should be lagged and compressed air mains fitted with drain plugs.

53

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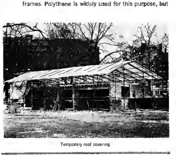


Temporary roof covering.

there is a wide range of other plastic materials such as p.v.c., nylon and terylene, which may be bought in sheet form.

(b) **inflated enclosures** which are independent structures maintained in position by a continuous flow of pressurised air, or by inflated ribs in which a pressurised flexible pipe forms a structural frame, the covering may be of any suitable material. This type of shelter completely encloses the building work.

(c) **drapes** which may be used for the protection of new work or for the protection of working areas. These may be of tarpaulin, polythene sheeting or any other suitable flexible material. The method of fixing depends upon the nature of the job. The advantage of polythene in this application is its translucence. Where the transmission of light to the working area is desirable, and tarpaulin is to be preferred to polythene, white tarpaulins may be used.

62

Windbreaks are necessary on sites where operatives in certain trades may be required to spend prolonged periods working in one location in exposed conditions and in near freezing temperatures e.g. pipe and bar bending, carpentry for formwork. They may also be used to protect vulnerable plant areas, such as concrete mixer stations and to protect new work from the effects of high winds and driving rain.

Concrete mixer station

63

Contact covers, consisting of tarpaulins or polythene sheeting, should be used to protect materials which may be damaged by rain, frost or snow, and cannot economically be stored in permanent shelters. They should also be used for new and partly finished work which requires cover from rain, snow and frost and, in exposed positions, from high winds: in some cases heat under the covers may be required.

Storage and protection of materials on the site

64

Most building materials should be protected from the weather during storage. Certain materials, such as reinforcing steel and cast iron pipes suffer no direct damage from limited periods of exposure, but work is delayed if they are encrusted with snow and ice. Inadequate and unsatisfactory storage can lead to loss of materials dispersed about the site, particularly if the site is muddy. Where possible, the building itself should be used as storage space. The following precautions should be taken:

(a) **sand and aggregate** must be protected from frost. The stockpile may be kept warm by local heaters such as salamanders or electric blankets, or covered with tarpaulins insulated by a suitable material such as straw-matting. Alternatively, a simple network of perforated pipes with blanked off ends may be laid near the bottom of stockpiles, so that if there is a danger of freezing, a steam plant may be brought to the site and connected to the network.

(b) **bricks, blocks and tiles** should be kept dry. They should be properly stacked off the ground on a simple platform, and should have protection in the form of well anchored tarpaulins or plastic film to protect the stack from rain.

(c) **bagged cement, lime and plaster** should be stored in a weathertight building with a floor.

(d) **insulation and plaster boards and similar finishings** readily absorb moisture and must be kept dry, preferably in heated, covered storage.

(e) **timber** which is to be incorporated in any part of a building should never be left lying fully exposed. It should be protected from the effects of weather in transit, on the site, and until it is incorporated in the building. The site storage period should be reduced to an absolute minimum. Where it is anticipated that a period of site storage under adverse conditions may arise, treatment with moisture retardants, particularly on exposed end grain is advisable before delivery to site. Storage should be designed where possible for easy access, and removal of any particular size and length required. **Air dried timber** should be stored in the stick under cover. **Kiln dried timber** should be stored close piled. The delivery and fixing of internal finishings should be delayed until the heating system is in use and the building is dry, and at the temperature at which it will ultimately be maintained. These conditions are essential in the case of kiln dried hardwood flooring. Failure to observe these requirements will increase the moisture content of the timber above the required limit.

(f) **prefabricated joinery components,** flush doors, etc should be stored under cover, preferably in a dry, ventilated room and stacked flat or in such a manner as to avoid deformation, twisting or accidental damage.

(g) **paint** should be stored in a frost free location, since many types are susceptible to frost.

65

Advice on appropriate precautions may be obtained from trade associations and federations, a short list of which is at Appendix III.

Lighting

66

Poor light is the most predictable of all the winter conditions which affect the building industry. Except where artificial lighting is used to extend hours available for work, it exercises a greater influence than any other factor on winter production.

67

Consideration must be given to the increased use of artificial lighting both for internal and external work. Good lighting is a prerequisite not only for increased productivity, but also for safety of operatives on the site—provided that the lighting system designed is inherently safe.

68

Earth works, concreting, drain laying, brickwork, and all the outside jobs can successfully be continued after dusk by the provision of suitable floodlighting. The provision of external lighting should be planned at the beginning of any job which is likely to continue during the winter months. The disposition of the lighting may be calculated; a guide as to the amount of light that is required may be taken from the following:

Exterior site work and open areas	1.0 lumen per sq. ft.
Reinforced concreting in shuttering	3.0—4.5 lumens per sq. ft.

The intensity of the light on the ground is related to the efficiency of the light source and its height above the working plane, but, if highly contrasting shadows and glare from the light source are to be avoided, the height of the mounting should not be less than 25 ft. For the suspension of any type of floodlighting a good secure fixing such as a tower crane or existing building is required. Failing this, a solidly constructed tubular scaffolding tower may be erected. Even when adequate general lighting is provided outside, a higher degree of illumination for certain operations, e.g. around the concrete mixing plant, may be necessary. There are many suitable light mount-

Almost equal to daylight; and certainly adequate illumination from only 3 floodlights

Site lighting

79

Normal stripping times for formwork are usually given in the specification and the adjustment necessary to this time will depend on the concrete having hardened sufficiently:

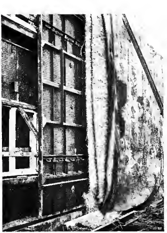
(a) to resist subsequent freezing without damage.

(b) to carry the loading asked of it.

For beam sides, walls, and columns (unloaded) it is generally only necessary to satisfy (a). A satisfactory time can be assessed for this by relating the requirement to a cube strength. Various figures are to be found in use from 500 lbs. per square inch upwards, but a conservative figure would be 1000 lbs. per square inch which, if the concrete is maintained at say 50°F. (10°C.), could be reached in three days. For members required to carry loads, conditions (a) and (b) must be satisfied and the props must remain in place until the requisite strength is reached. 'The Report on Concrete Practice' issued by the Institution of Structural Engineers and the Cement and Concrete Association (see item 24 in Appendix III) suggests adding to the normal stripping time half a day for each day in which the temperature was generally below 45°F. (7°C.) and a whole day for each day on which the temperature was generally below 35°F. (2°C). A more precise approach may be achieved by taking regular temperature checks, adequate test cubes stored under the same conditions as the work, and controlling the curing temperature.

80

In all cold weather working the use of thermometers is essential and complete temperature records should be maintained. If the temperature of the hardening concrete is to be taken, this can be facilitated by the use of short perforated metal tubes set in the concrete, or by the formation of any small pocket to permit the insertion of a thermometer.



Straw and covers protecting concrete.

81 Table 5. Insulation

Type	Materials	Remarks
Shuttering	Timber board as normally used Forms backed with straw, etc. Forms backed with closed air space formed by building paper, etc., tacked over battens.	Where timber formwork is used, this may provide sufficient insulation in itself to the surfaces it contains Steel shuttering has very low insulating value and readily conducts heat away to other parts of structure as well as losing it to the air Back with straw, etc.
Top cover	Several layers of building paper, sacking cement bags, etc 6 in. or more of straw or similar materials. Boards with canvas over. 6 in. to 24 in. air space over slabs and pavings formed by stretching canvas over wood frames	Adequate lapping and tacking down at edges is important. Sacks, etc., kept dry by sheeting over with tarpaulin or building paper provide better insulation Considerably improved by tarpaulin over Heat sometimes applied under the enclosure.
Enclosures	Complete covering of the job by thick canvas sheeting, etc., allowing 18 in. air space all round the work. Enclosure is heated	For severe conditions care must be taken to avoid all unnecessary openings

Ready-mixed concrete

82

During winter, ready-mixed concrete offers to the contractor an opportunity of transferring one of his problems to the supplier. The supplier's main problem in winter weather is probably the maintenance of continuous supplies of suitable materials.

83

In ready-mixed concrete depots, steam is normally employed to defrost bins, hoppers and their contents. Where steam is applied direct to aggregates, the amount of water added in mixing has to be reduced to allow for the moisture content in the aggregate.

84

The measures to be taken in the preparation of ready-mixed concrete are the same in principle as those applying to site mixed concrete. When concrete is transported by agitator, the water is added at the depot, and experience indicates that there is little drop in temperature during transportation. When water is added en route or on site, however, the vehicle's water tank may need to be filled with hot water: when long distances are to be covered, provision may have to be made for maintaining the temperature of the water

85

Restrictions in specifications on the placing of concrete in cold weather seriously affect ready-mixed concrete suppliers. The incentives for them to develop further means of protection against frost would be greatly increased if these restrictions were modified, as suggested in paragraph 34.

Precast concrete

86

Precast concrete offers advantages over conventional reinforced concrete because of the increased speed of construction possible, and its relative freedom from the influence of frost. However, although these advantages are sufficient to influence choice in its favour in countries with prolonged winters, selection is not normally influenced by these considerations in Britain. Other factors, such as overall economy, the type of structure, the function of the building, the distance from the precast factory to the site and the possible need for carrying out the precasting on site have to be taken into account.

87

The erection of floor units, stairs, etc., can proceed with the minimum of precautions, and roofs or floors of precast units offer an early cover for other work. Items such as these could well be considered at the planning stage to help maintain the programme.

88

Where precast frames are used, protection from frost will be required only at the joints, where it can often be reduced to simple box type covers containing insulation or some means of heating. The heat of electric light bulbs is often sufficient Column base joints will require insulation and covering.

89

If overall temporary enclosures are contemplated, the erected framework can form the basis for the covering, to enable work in other trades to proceed,

Brickwork

90

Bricklaying in winter in the open requires special protective measures:

(a) **Protection of materials**

If bricks become saturated by rain, they will be far more liable to damage by frost, and efflorescence is more likely to occur. Further, their slowness in drying out will result in delays to other trades, such as plastering and decorating, and may well lead to other defects in the finished building. Consequently, bricks should be kept off the ground, stacked and covered with light protection such as tarpaulins Provided they are kept dry, frost will not affect them. The lime and cement contents of mortar are normally stored under cover, but precautions should be taken with sand to avoid the inclusion of particles of ice. In severe frosts, both materials and mixing plant should, if possible, be housed in an enclosure.

(b) **Preparation of mortar and general treatment**

(i) Mortar for brickwork should not generally contain too much cement, but in cold weather it is usual to increase the cement content (the Building Research Station recommends 1 : 1 : 6 cement/lime/sand or 1 : 6 cement/sand with plasticizer) so that the mortar will harden more rapidly and offer resistance to frost. Mortar plasticizers of the air entraining type offer some help in improving the resistance of the freshly laid mortar to frost, but the use of 'anti-freeze' compounds is not advised. The heat generated by such additives is rapidly dissipated into the adjacent cold bricks, and much of the additive in the mortar is drawn with the water into the surrounding bricks. Further, if calcium chloride is present, and this appears to be the basis of most 'frost proofing' additives, since it is a deliquescent salt, that portion of it retained in bricks will remain as a potential source of dampness and deterioration.

(ii) When night temperatures fall no lower than 25°F. (−4°C.), only very simple precautions such as keeping bricks dry, using stronger mortar, and covering the completed work at night, need be used.

(iii) In extreme conditions, when the temperature falls to the region of 14°F. (−10°C.), mortar should be heated, the most simple method being to heat the water to 120-150°F. (49-66°C.). In extreme conditions, sand and perhaps bricks also should be heated, in which case the water content in the mortar will need to be increased. The builder should aim to provide a mortar with a temperature of 60-80°F. (16-27°C.), which will still be above freezing point when the work is completed and covered. Mortar may be kept warm before use on a steel sheet over a stove.

Bricklaying under temporary protection

(c) **Protection of completed work**

On completion, new brickwork should be covered and protected for three to seven days, according to the extent of frost. The temperature of the brickwork must not be allowed to fall below freezing point, and the provision of heat under the covers may be necessary. The rate of hardening of the mortar will be affected by low temperatures in the same way as concrete, and the period of protection has to be related to achieving the required strength.

Roofing

91

Early completion of the roof will enable inside work to proceed, protected from the weather. If it is not possible to carry out tiling or slating, the felting and battening will give some measure of protection to the building.

92

In flat roof construction a screed is often required before the application of the final weather proofing, and the information given in the concrete and flooring sections is, in the main, applicable. There is, however, the need to take the additional precaution of protecting against rain and freezing. Thorough drying out of lightweight screeds and the inclusion of suitable ventilation should be assured.

93

Felt and asphalte coverings can only be satisfactorily applied when the roof deck materials are in a dry state. If undue delays are to be avoided, it may be necessary to protect the roof deck from rain as it is laid. Where absorbent roof decking, such as strawboard, is used, this is of the utmost importance as, under winter conditions a long delay is likely to occur if it has to be dried out. Development work is proceeding on underlays which, in certain circumstances, may allow asphalte roofs to be laid on a wet screed.

94

Roofing is one of the most exposed trades, and conditions in which the operatives are required to work must be considered. Most final roof coverings are undertaken by specialist firms, who should advise whether conditions are suitable for them to carry out their work.

Plastering

95

Once the shell of a building is up, the speed of final completion is largely dependent upon the rate of drying out of the water used during construction. The natural rate of drying is at its lowest during the winter months, when humidity is high and the average temperature is low. Plastering introduces more moisture into the building at this stage than any other operation, and thus creates delays for other finishing trades. Excessively cold conditions can bring traditional plastering to a halt, since it is not practicable to continue when there is likelihood of the fresh plaster freezing, or when the surfaces to be plastered are very cold.

96

It may be advisable to examine the specification to ensure that the plaster used is suited to the weather conditions. Special plasters are now available which obviate the need to wet high suction backgrounds. Generally, gypsum based plasters are, because of their rapid hardening properties, more suited to winter conditions than those containing lime and cement. If, however, use of lime and cement is unavoidable, ready mixed mortars merit serious consideration as they can be made up under conditions free from frost. An aerated cement/sand undercoat will help to isolate the finishing coat plaster from any moisture in the wall, and will reduce the risk of subsequent efflorescence.

97

Whatever type of traditional plaster is used, precautions will have to be taken if work is to continue under winter conditions. The following are used:

(a) **the part of the building to be plastered should be completely enclosed.** If glazing has not been carried out, translucent sheeting should be fitted over window frames. All external door openings should be closed and the minimum number of entrances allowed for use; these should be fitted with a self-closing device.

(b) **heat should be introduced.** This should raise the temperature to a level at which plastering may safely and satisfactorily be carried out, and will increase the rate of drying out, thus facilitating the progress of other finishing trades. Heat should be maintained at least until the completion of hydration, which normally takes twenty-four hours. Ideally, and this is a matter for consideration during the course of planning, the permanent heating installation should be utilised as the heat source, but, where this is not possible, use may be made of portable heating appliances, of which many types, such as braziers, salamanders and blowers, are available, or of the ordinary domestic heating appliances. Care must be taken to avoid excessive localised drying out.

(c) **adequate ventilation is required** to minimise condensation induced by gas fuels, to aid drying out, and in the interests of safety.

98

At the design stage, consideration should be given to the use of dry lining techniques. Even whilst a job is in progress, it may become desirable to adopt this form of finish in preference to traditional plastering, to avoid excessive delays in completion.

Floor Finishes

99

Special care and precautions must be taken when dealing with most types of floor finishes in winter. Floor laying is almost always carried out inside the nearly completed building, and it should be possible, therefore, to provide the essential atmospheric conditions. For moisture sensitive finishes such as linoleum and p.v.c. the essential requirement is that the sub-floor should be at the right state of dryness and this can be checked accurately by use of moisture meters.

100

Specific precautions cannot be stated for every type of floor. Most are, in any case, laid by specialist firms who should be called upon to advise the builder whether or not conditions are suitable. The screed is, however, common to most types of flooring, and the information contained in the section on concrete is, in the main, applicable. Where it is impossible to provide heat for the laying and curing period, the use of rapid hardening cement may be of assistance in marginal temperature conditions. Screeds should not be laid when the air temperature is falling below 38°F (3°C.). The same conditions apply to granolithic topping. The setting and hardening of Portland cement may be accelerated by adding 2 to 2½ lbs. of calcium chloride to 112 lbs. cement, dissolved in the mixing water; alternatively, an extra rapidly hardening Portland cement may be used. The freshly placed concrete should not be allowed to freeze and, if necessary, should be covered with sacks, tarpaulins or plastic sheeting supported from 6 to 18 inches above the surface.

101

Attention must be given to storing on site and laying of wood floorings, since they are generally delivered to the site dried to the required moisture content, and readily reabsorb moisture. They should only be laid when the building is dry, and at the temperature at which it will ultimately be maintained.

Painting and decorating

102

In the summer months, the painting and decorating trade is usually overloaded with work, whilst in the winter, it suffers the highest rate of unemployment, proportionate to its size, in the construction industry. Since 85 per cent of the work of the trade is maintenance of existing buildings, much of which could be carried out as easily in winter as in summer, the problem of winter unemployment seems to arise from the apparent inability or reluctance of clients to commission work in winter. Of the 15 per cent of the trade employed on new work, the low level of productivity in the winter may be attributed to the greater inherent risk of failure, rather than to the physical difficulty of application.

103

Moisture is the principal cause of failure. Before decorating is started, surface moisture can be measured with a moisture meter. Dryness on the surface does not imply dryness throughout. In summer, climatic conditions usually reduce the drying out period to within acceptable limits. In winter, if completion is not to be unduly delayed, artificial aids must be used. The rate of drying out may be substantially increased by the introduction of warmth with adequate ventilation, using any of the means of heating described in the section on plastering, or by the use of dehumidifiers, of which a number of types are now available for purchase or hire. Care must be taken in the selection of the type of decoration used in new work. A porous decoration which will allow drying out to continue is usually preferable. Appendix VI describes paints which are suitable for early decoration.

104

New woodwork to be painted is best sealed against moisture by the application of a good primer before delivery to the site. Surfaces exposed during fixing should be touched up immediately.

105

Many quick-drying paints are now available for outside painting. Thorough brushing and the use of hydro additives (advice on which can be obtained from most manufacturers) can reduce the possibility of trouble when surface dampness occurs. As the hours when conditions are suitable for outside work are limited in winter, it is always advisable to have some inside work available.

CARE OF PERSONNEL

Protective clothing

106

The design and provision of appropriate clothing which is resistant to moderate rain, cold and wind should be considered.

107

There are many types of protective clothing which will meet these requirements, but all tend to restrict easy movement, and thus reduce the rate of production. The need is for garments which are rainproof and windproof, warm, light and easy to wear, strong enough to withstand the rigours of construction work, and affording such freedom of movement as is required for the trade for which they are designed. The importance of one factor as opposed to another in this comprehensive specification will depend in large measure upon the trade of the wearer: a steel erector will need light clothing and footwear allowing complete freedom of movement, whereas a labourer will require heavy, water-resistant footwear and garments which will withstand extremely heavy wear and tear.

Safety

108

Ice, snow, high winds, poor light and intense cold present hazards to the operatives. Icy surfaces on the ground or on any working plane are always a menace and the cause of many accidents. They are particularly dangerous on scaffolding, ladders, structural steel, and at any height where the results of a fall could be fatal. A supply of common salt should be available for the immediate removal of ice, but care must be taken to ensure that it does not accidentally damage the work.

109

Constant attention to the problem of safety is most important in winter and, although responsibility rests upon site management to ensure that the conditions for work are at all times safe, the operatives themselves have a special duty to watch for and to report hazards as they develop.

110

Some of the measures taken to enable work to proceed under adverse conditions may constitute a danger to safety. Men have been badly scalded by steam pokers used for de-freezing, electrocuted by temporary lighting installations, and badly burned by the 'flare up' of temporary heating appliances. Operatives should be trained in the use of equipment and warned of its dangers.

111

Most accidents may be avoided if due care and thought is exercised by everyone on the site.

Welfare

112

Adequate site facilities for the welfare of the men are desirable at any time of the year. In winter, when exposure to adverse weather conditions will create considerable discomfort to the operatives, messrooms should be heated and adequate arrangements made for drying clothes. Provision should be made for heating food and for the supply of hot beverages in the messrooms or, in critical operations, at the place of work.

APPENDIX I

DEPTH OF GROUND FREEZING

Paper by Dr. W. H. Ward, Building Research Station

The depth to which the ground freezes is determined by:

1. the depression of the air temperature below the freezing point of water;
2. the duration of sub-freezing temperatures;
3. the thermal properties of the ground and its cover (conductivity, heat capacity and latent heat).

The latter properties vary appreciably from site to site and annually at a given site. For example, a few inches of snow or a grass/turf cover reduce the frost penetration very considerably below that under bare ground. Also, the same site when waterlogged will be frozen much less deeply under given air temperature conditions than when it is well-drained. The behaviour and properties of frozen soil also vary appreciably. The freezing of saturated very fine sands, silts, or chalk, gives rise to a large expansion which can be many times greater than the volume expansion of water into ice and is known as 'frost heave'. This process is responsible for most of the uplift and cracking of thin pavements and slabs. Heavy clays and coarse sands and gravels are much less likely to exhibit frost heave. The difficulty of excavating frozen grounds also varies with the type of soil and the degree of saturation at the time of freezing. Saturated silty soils are significantly more difficult to dig when frozen. Coarse sands and gravels are little altered and heavy clays affected only to a small extent.

The winter temperature conditions in Britain are, on average, so mild that the ground is rarely frozen to a depth of more than one or two inches. A rough guide to the depth of frozen ground may be obtained from the thickness of ice found on small lakes and ponds. In the exceptionally cold winters which occur only once or twice a century when the mean daily air temperature is below freezing for a month or more, the greatest depth of frozen ground is not likely to be more than 2 feet, and this depth will only be reached in bare well-drained sands or gravels. Pipes conveying very cold water and buried within 2 or 3 feet of the surface will increase the depth to which the soil is frozen.

The total degree days below 32°F. (0°C.) base temperature in a season is a useful index (the freezing index) of the depth to which a given sample of ground may be expected to freeze. For the last cold spell the total frost degree days at Garston amounted to 240. In the table below the maximum depth of frost penetration in several types of ground which are bare at the surface are estimated for this period. All other types of soil, except organic material such as peat, would be frozen to depths within the limits indicated. The depth of 22 in. agrees well with the observations of the maximum depth of frost recorded under roads kept clear of snow. This depth is almost certainly the most the ground has been frozen since 1890/1.

Freezing index 240

Well-drained sandy gravel	– 22 in.
Saturated silty sand	– 13 in.
Saturated clay	– 7 in.

METEOROLOGICAL INFORMATION

1 Forecasts may be obtained from the following Meteorological Offices:

(a) Obtainable at any time of the day or night.

LONDON (Princes House)	Temple Bar 4311
ALDERGROVE (Nr. Belfast)	Crumlin 339
BAWTRY (Nr. Doncaster)	Bawtry 474
DUNFERMLINE (Pitreavie)	Inverkeithing 266
GLASGOW WEATHER CENTRE	City 3451
GLOUCESTER	Gloucester 23122
LYNEHAM (Wilts)	Bradenstoke 283
MANBY (Lincs)	Louth 2145
MANCHESTER WEATHER CENTRE	Deansgate 6701
MILDENHALL (Nr. Newmarket)	Mildenhall 2274
NOTTINGHAM (Watnall)	Nottingham 55155
PLYMOUTH	Plymouth 42534
PRESTON	Preston 2628/9
SOUTHAMPTON WEATHER CENTRE	Southampton 28844
UPAVON	Upavon 286

(b) Normally obtainable during office hours subject to the office being open for operations.

ABERDEEN (Dyce)	Dyce 331
ABINGDON (Berk)	Abingdon 1408
ACKLINGTON (Northumberland)	Red Row 369
*BASSINGBOURN (Herts)	Royston 2271
BIRMINGHAM AIRPORT	Sheldon 4747
BOSCOMBE DOWN (Wilts)	Amesbury 3331
CARDIFF (Rhoose)	Rhoose 343
*CHIVENOR (Devon)	Barnstaple 2241
KINLOSS (Morayshire)	Forres 261
KIRKWALL AIRPORT (Orkneys)	Kirkwall 421
LECONFIELD (York)	Leconfield 386
LEUCHARS (Fife)	Leuchars 271
LIVERPOOL (Speke)	Garston 4666
*LINTON-ON-OUSE (York)	Linton-on-Ouse 261
MARHAM (Nr. Kings Lynn)	Narborough 261
*MIDDLETON ST. GEORGE (Nr. Darlington)	Dinsdale 444
OAKINGTON (Cambridge)	Cambridge 56441
RONALDSWAY (Isle of Man)	Castletown 3311
ST. MAWGAN (Cornwall)	Newquay 2224
SHAWBURY (Nr. Shrewsbury)	Shawbury 335
THORNEY ISLAND (Hants)	Emsworth 2355
TURNHOUSE (Edinburgh)	Corstorphine 2351
VALLEY (Holyhead)	Holyhead 2241
WITTERING (Northants)	Stamford 2251
WYTON (Hunts)	Huntingdon 251

*Offices not open on Saturdays or Sundays. Subscribers should ask for the Forecasting Office

2. Advice on weather prospects based on past experience may be obtained by applying to:

The Director General, Meteorological Office, Bracknell, Berkshire
Telephone Bracknell 2420

or 26 Palmerston Place, Edinburgh 12
Telephone Caledonian 6561

or Tyrone House, Ormeau Avenue, Belfast 2
Telephone Belfast 28457

3. Further details may be obtained from Ministry of Works Advisory Leaflet No. 40, 'Weather and the Builder' and Meteorological Office Leaflet No. 2. Both are due for revision.

APPENDIX III

SOURCES OF FURTHER INFORMATION

Part I—Selected References

The titles listed have been selected by the Committee as useful sources of further information.

Weather	1	**Weather and the Builder** Ministry of Works Advisory Leaflet No. 40. Due for revision
	2	**Meteorological Office Leaflets Nos 1 and 2** Meteorological Office Contain details of available services Due for revision.
	3	**RILEM Recommendations for Winter Weather Forecasting Systems for the Building Industry, January 1963.** RILEM Winter Construction Committee, International Association of Testing and Research Laboratories of Materials and Structures. Reviews specialised meteorological services required by the building industry.
Planning	4	**The Critical Path Method Parts 1 and 2** The Builder 14th and 21st June, 1963. Two articles on a method of planning and controlling work
Temporary Protection	5	**Plastics in Building Operations by D. Bishop, A.M.I C.E., A.R.I.C.S.** National Builder, December 1961 Includes application of plastics for enclosures.
	6	**Building under cover** Series of articles in Master Builder, 1961-63 Continuing appraisal of development in building protection.
Lighting	7	**The Lighting of Building Sites and Works of Engineering Construction** Illuminating Engineering Society Technical Report Number 3.
	8	**Temporary Lighting on Building in Course of Construction and Civil Engineering Projects by J. Gordon Scott** The British Journal of Industrial Safety, Volume 4, Number 49, Autumn, 1959.
	9	**Use of Mains Electricity on Building Sites by J. Crisp, Associate I E.E.** Electrical Times 5th July, 1962.
	10	**Lighting Sites Increases Safety by D C. Pritchard** Plant Hire and Contractor's Equipment, March April, 1963.
	11	**Temporary Electrical Installations and the Safe Use of Electricity in Building Work** London Master Builders' Association, Technical Information Service Bulletin, Number 15, March, 1961.
	12	**Regulations for the Electrical Equipment of Buildings, Appendix 'A'** Institution of Electrical Engineers This appendix refers to private generating plant and secondary battery installations.

SOURCES OF FURTHER INFORMATION

Part I—Selected References

Concrete and Brickwork

13 **Concreting and Bricklaying in Cold Weather**
Building Research Station, National Building Studies Bulletin Number 3

A comprehensive description of bricklaying and concreting in cold weather and the recommendations by the Building Research Station.

14 **Concreting in Cold Weather**
Ministry of Public Building and Works Advisory Leaflet Number 7

A useful pamphlet abridged from 13.

15 **Bricklaying in Cold Weather**
Ministry of Works Advisory Leaflet Number 8

A useful pamphlet abridged from 13

16 **Concreting in Cold Weather**
Cement and Concrete Association 'Man on the Job' Leaflet Number 19.

A short guide for site staff

17 **Cold Weather Concreting by N. M. Brydon, M.E.E., B Sc., M I C.E., M.I Struct.E.**
Reinforced Concrete Review, Journal of the Reinforced Concrete Association, December, 1959

Comprehensive technical paper for the engineer, includes heating of the mix and temperature control.

18 **Miscellany**
Building Research Station Digest Number 96

Authoritative note on frost proofing additives for mortar.

19 **Explanatory Handbook on the British Standard Code of Practice for Reinforced Concrete by W L. Scott, M.I.C.E., M.I.Struct.E., W. H. Glanville, C.E., C.E.E., D.Sc., Ph.D., M.I.C.E., M.I.Struct.E., and E. G. Thomas, Ph.D., B.Sc., M.I.C.E., M.I Struct E.**
Concrete Publications Ltd., Number 114. 1957.

British Standard recommendations and commentary for concreting, including cold weather precautions.

20 **A Review of Ready-Mixed Concrete Developments by V. S Wigmore, F.S E.**
Reprint from 'Cement, Lime and Gravel', January and February, 1962

A general article on ready mixed concrete, not specifically directed to winter working

21 **Proceedings of the RILEM Symposium Winter Concreting, Session E**
Danish National Institute of Building Research.

A series of papers produced at the 1956 Symposium on Winter Concreting in Copenhagen.

22 **Cold Weather Ready-Mixed Concrete**
National Ready-Mixed Concrete Association Publication Number 34, September, 1960.

American publication on concrete productions includes calculations of heat requirements

SOURCES OF FURTHER INFORMATION

Part I—Selected References

Concrete and Brickwork (Contd.)	23	**Winter Concreting Trends in Europe by E. G. Swenson** National Research Council, Canada, Division of Building Research Technical Paper No. 48 A review of developments based on the papers produced at the RILEM symposium, with observations
	24	**Report on Concrete Practice, Part 1—Materials and Workmanship** Institution of Structural Engineers and Cement and Concrete Association. Up to date report on concrete practice, which includes cold weather working.
Plastering	25	**Dry-lined Interiors to Dwellings** Building Research Station Digest Number 9 (Second Series)
	26	**Recent Investigations on Mortars, Plasters, and Rendering by J. F. Ryder B.Sc.** The National Builder, November, 1961.
Floor Finishes	27	**Laying Screeds as an Underlay for Floor Coverings** Ministry of Works Advisory Leaflet Number 5
	28	**In Situ Flooring** British Standard Code of Practice Number CP 204(1951)
	29	**Wood Flooring** Timber Research and Development Association, Revised May 1959.
	30	**Hardwoods for Industrial Flooring** Department of Scientific and Industrial Research, Forest Products Research Laboratory Leaflet Number 48, September 1954.
	31	**Wood Floors** Timber Research and Development Association
	32	**Timbers for Flooring by F. H. Armstrong** Department of Scientific and Industrial Research, Forest Products Research Laboratory Bulletin No. 40, 1957.
	33	**Timber Flooring** British Standard Code of Practice Number CP 201(1951)
Painting	34	**Painting** British Standard Code of Practice Number CP 231 (1952)
	35	**Painting New Plaster & Cement** Ministry of Works Advisory Leaflet No. 1.
	36	**Miscellany** Building Research Station Digest Number 96 A guide to the measuring of dampness of walls to be decorated.
General	37	**Winter Working in Building and Civil Engineering** Report by a Sub Committee set up by the Ministry of Works Joint Advisory Panel for the Building and Civil Engineering Industries in Scotland to examine and report on Winter Working. Building Industries and Scottish Architect, January, 1960. A general report on the broad terms of winter working.

SOURCES OF FURTHER INFORMATION

Part I – Selected References

General (Contd)	38	**Working in Winter or Bad Weather** Building Research Station Digest No. 3 (Second Series) A general review of winter working.
	39	**Winter Construction by C. R. Crocker and D. C. Tibbetts** National Research Council, Canada, Division of Building Research Better Building Bulletin No 6, December 1960 Canadian advisory booklet
	40	**The Construction (General Provisions) Regulations 1961** Statutory Instrument No. 1580 of 1961 Law affecting safety and working conditions

Part II – General References

The titles listed are of interest for supplementary reading

Weather	41	**A Century of London Weather by W. A. L. Marshall** Meteorological Office, Air Ministry, 1952
	42	**Climatological Atlas of the British Isles** Meteorological Office, Air Ministry
	43	**An Index of Exposure to Driving Rain** Building Research Station Digest No. 23 (Second Series)
Temporary Protection	44	**Building in Winter with the Aid of Enclosures by A. W. Smith** National Research Council, Canada, Division of Building Research Technical Paper No 65
	45	**A Plastic Shelter for House Building in Winter** National Research Council, Canada, Division of Building Research Technical Paper, Number
	46	**Building in Comfort in a Nylon Airhouse** Engineering, 16th December, 1960
	47	**Precast Concrete for Winter Building by C. R. Crocker M E I C. and A. W. Smith** National Research Council, Canada, Division of Building Research Technical Paper No 82
	48	**Rapid Construction of Foundations in Frozen Ground** Concrete and Constructional Engineering, November, 1942
	49	**Infra-red Rays protect Winter Brickwork at cost of $1 25 for 16 hours** Brick and Clay Record, February 1949
General	50	**Winter Construction in Ontario by H. Rhys Davies, B.Eng., P.Eng (Ont)** Civil Engineering and Public Works Review, November 1954
	51	**Winter Construction by C. R. Crocker, M.E.I.C.** National Research Council, Canada, Division of Building Research Technical Paper Number

Part II—General References (Contd.)

General (Cont)	**52**	**Winter Construction by B. Näslund** National Research Council, Canada, Technical Translation TT-583
	53	**Winter Construction by C. R. Crocker, M.E.I.C.** National Research Council, Canada, Division of Building Research Paper No. CBD7.
	54	**Practical Experience of building in Winter by W. Ott** Bundesbaublatt, November, 1956
	55	**Building all the Year round** Danish National Institute of Building Research Directives Numbers 48 and 49, 1959
	56	**Building Research 1962** Department of Scientific and Industrial Research
	57	**Wood in Buildings** Timber Research and Development Association, May 1963

Part III—Sources of Advice and Information

Lighting	
British Lighting Council, 16-18, Lancaster Place, London, W.C.2	Temple Bar 7337
Heating and Ventilating	
Heating and Ventilating Research Association, Old Bracknell Lane, Bracknell, Berkshire	Bracknell 2071-3
Concrete and Brickwork	
British Ready Mixed Concrete Association, 19, The Crescent, Ilford, Essex	Valentine 4133
Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1.	Belgravia 6661
Federation of Building Block Manufacturers, 5, Elm Road, Beckenham, Kent	Beckenham 4505
Reinforced Concrete Association, 94-98, Petty France, London, S.W.1	Abbey 4504
Sand and Gravel Association of Gt. Britain, 48, Park Street, London, W.1	Grosvenor 8967
Sandlime Brick Manufacturers Association Ltd., Hanover House, 73-78, High Holborn, London, W.C.1	Holborn 5434
Roofing	
Felt Roofing Contractors' Advisory Board, Victoria House, Southampton Row, London, W.C.1	Holborn 0670

Floor Finishes

Association of Constructional Floor Specialists, Victory House Annexe, Leicester Square, London, W.C.2.	Gerrard 5738
Association of Flooring Contractors, 14, Bryanston Street, London, W.1.	Walbeck 1781

Asphalte

Mastic Asphalte Advisory Council, 14, Howick Place, London, S.W.1.	Victoria 1600 and 6477

Timber

Timber Research and Development Association, St. John's Road, Tylers Green, High Wycombe, Bucks	Penn 2261

Paint

Society of British Paint Manufacturers Ltd., Grosvenor Gardens House, Grosvenor Gardens, London, S.W.1.	Victoria 2186

General

Advisory Service for the Building Industry, 82, New Cavendish Street, London, W.1.	Langham 5233/6
British Standards Institution, 2, Park Street, London, W.1.	Mayfair 9000
(The) Building Centre, Store Street, London, W.C.1.	Museum 5400
Building Research Station, Garston, Watford, Herts.	Garston 4040
Contractors' Plant Association, Hanover House, 73-78, High Holborn, London, W.C.1.	Holborn 5434
Federation of Civil Engineering Contractors, Romney House, Tufton Street, London, S.W.1.	Abbey 2544
Institute of Builders, 48, Bedford Square, London, W.C.1.	Museum 7197
London Master Builders' Association, 47, Bedford Square, London, W.C.1.	Museum 3891
National Federation of Builders' and Plumbers' Merchants, High Holborn House, 52-54, High Holborn, London, W.C.1.	Chancery 7772/7
National Federation of Building Trades Employers, 82, New Cavendish Street, London, W.1.	Langham 4041
National Federation of Building Trades Operatives, Federal House, Cedars Road, London, S.W.4.	Macaulay 4451

APPENDIX IV

TABLE OF LIGHT SOURCES, THEIR IMPORTANT ADVANTAGES AND LIMITATIONS

	Filament (G.L.S.)	Filament (T.I.)	Mercury/ Fluorescent (MBF MBFR)	Fluorescent (MCF)	Sodium (SO & SOI)
Wattage Range	40–1500	500–1500	50–2000	4–125	45–280
Efficiency (Lumens/Watt)	Low (10–18)	Fairly low 22	Medium (31–45)	High (50–74)	High (50–92)
Colour Rendering	Good	Good	Fair	Good	Bad
Resistance to Vibration	Poor	Fair	Good	Good	Good
Normal Life (Hours)	1000	2000	5000	5000	4000
Approx Initial cost per 10000 lumens of light (excluding control gear)	14/–d.	60/–d.	70/–d. MBF 90/–d. MBFR	22/–d.	66/–d.
Restrictions on lamp positions	None	Horizontal ± 4°	None	None	Horizontal*

*There is a fairly wide tolerance depending on wattage and lamp manufacturers should be consulted.

APPENDIX V

A few of the large range of lighting fittings available to the building industry for exterior and interior site lighting.

1 Sealed floodlight which is used with 100 to 1000 watt filament lamps. Suitable for wall fixing and can be used for lighting upwards

2 A combined lighting and power supply cable with the lampholders and sockets integrally moulded into the cable

3 Open floodlight which can be used with high wattage filament or mercury fluorescent lamp. Suitable for pole mounting or wall fixing

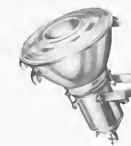
4 Telescopic tripod for mounting lighting equipment, made in a range of sizes depending on sizes of floodlight to be used

A portable heavy duty floodlight which uses a 300 watt filament lamp. The base acts as a cable drum and stand

5 A 150 watt pressed glass reflector lamp with weatherproof holder and bracket. This is suitable where additional lighting is required for special work

6 A compact floodlight which uses a 1000 watt tungsten iodine lamp. This fitting is very useful for lighting large open areas.

7 Simple fibre glass floodlight which is suitable for clamping to scaffolding and is designed for easy installation on external building sites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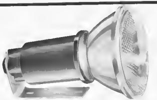
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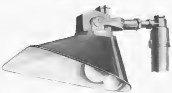
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POROUS PAINTS SUITABLE FOR EARLY DECORATION

NAME	TYPE	GENERAL PROPERTIES	CONDITIONS OF USE
Distempers	Oil-bound washable	Can be used as a permanent decoration. Can be redecorated with distemper or oil paints. Will withstand light washing if allowed to harden for some time. Most of these distempers are somewhat liable to alkali attack (in severe conditions)	Mainly for interior use, but some are made for exterior use Should not be used where alternate wetting and drying, e.g. due to condensation is likely. This may cause flaking, especially on highly trowelled surfaces.
	Oil-free non-washable (size bound)	Not fast to dry rubbing. Can readily be washed off, and must be removed before redecorating	Used where rubbing is unlikely, e.g. on ceilings.
Flat oil paints (some).	Porous, i.e. flat finish due to high-pigment-filler content	Provide a serviceable permanent decoration or a suitable base for redecoration More permanent than distempers Most are not resistant to alkali attack.	Can be used on all surfaces, but an alkali resistant primer may be needed Preferable to distempers where resistance to alternate wetting and drying or greater permanence is required The primer must also be porous.
Cement paints		Provide a hard durable matt surface. Resistant to chemical attack Can be redecorated with cement paint, but are liable to cause chemical attack on oil paints applied over them, unless precautions are taken	Mixing must be carried out strictly according to the manufacturer's directions. Especially suitable for use on exterior or interior surfaces of concrete, cement rendering or asbestos cement sheet. Should NOT be used on damp materials containing excess sulphates, e.g. gypsum plasters and some bricks.
Textured paints	Sometimes called "plastic paints"	In spite of the thick coat usually applied, plastic paints are fairly porous, unless a glaze coat is applied.	Mixing and application must be carried out strictly in accordance with the manufacturers instructions.
Emulsion paints	Polyvinyl acetate (matt or with slight gloss)	Porous (except gloss finish) and resistant to alkali attack. Can be used as a permanent decoration	Suitable for interior and, if properly selected, for exterior use Resistant to alkali attack, but not always to efflorescence, and never to powdered surfaces. Washability good as a rule, and one of the best general coats for early application to new plaster.